On the impact of the assimilation of nacelle winds and yaw angles with WRF-FDDA and WRF-DART for short-term wind energy predictions

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Assimilation of nacelle winds and yaw angles for Short-Term Wind Energy Predictions

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Forecast errors are expensive

- Trading of wind power on energy markets
- Fluctuating wind and power is challenging for grid operators
- Optimisation of power plant mix
- Maintainance planning
- Enhanced value and acceptance of wind power

Wind turbine measurements become increasingly available and constitute a new set of measurements in the PBL

? How to treat them in data assimilation?

What is their benefit in the system?

Nacelle winds and yaw angles

Nacelle winds and yaw angles are used by the turbine control system for optimal turbine operation.

Nacelle winds:

Sonic anemometers measure wind on Horns Rev turbines @ 70 m.

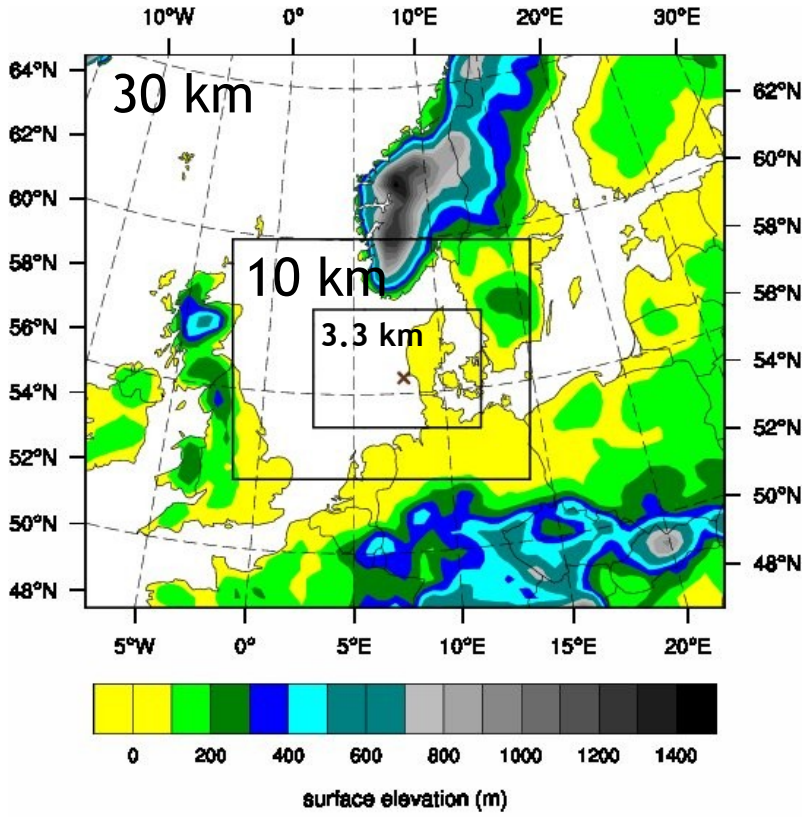
Yaw Angles for wind directions (u and v in data assimilation):

The nacelle turns itself into the wind.

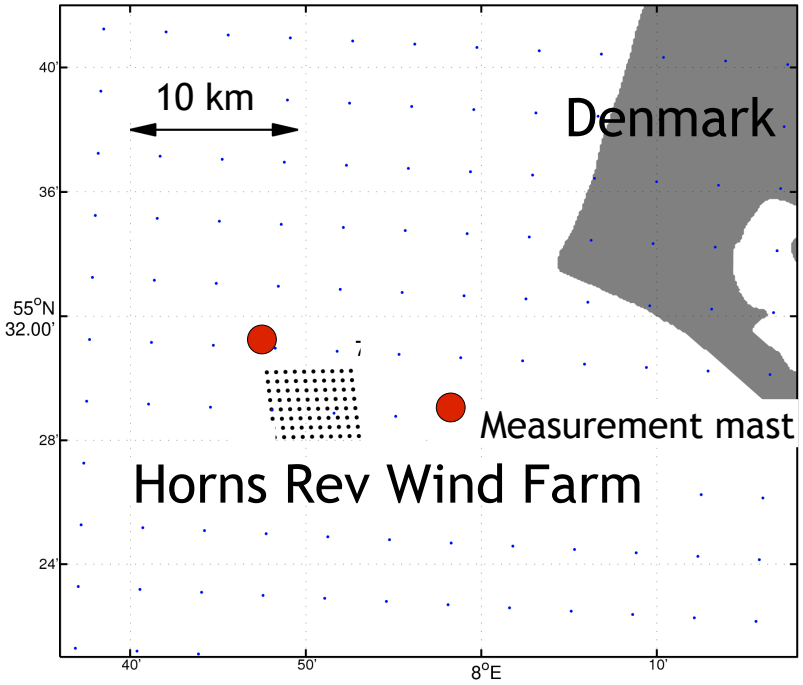
Issues with nacelle winds

- Disturbance depends on
  - Design of turbine and nacelle
  - Pitch/stall regulation
  - Height of anemometer and position on nacelle
  - Operation/standstill
  - Position in wind farm: wake
- Nacelle transfer function
- Restricted data access

Wind Farm layout and model setup



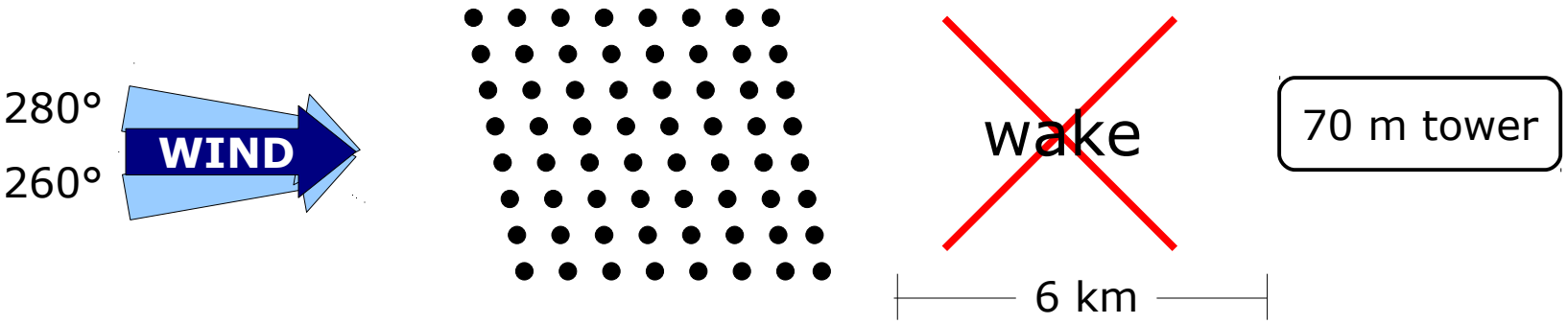
WRF FDDA V3.2.1



Assumption of spatially independent obs errors in data assimilation violated

=> data thinning

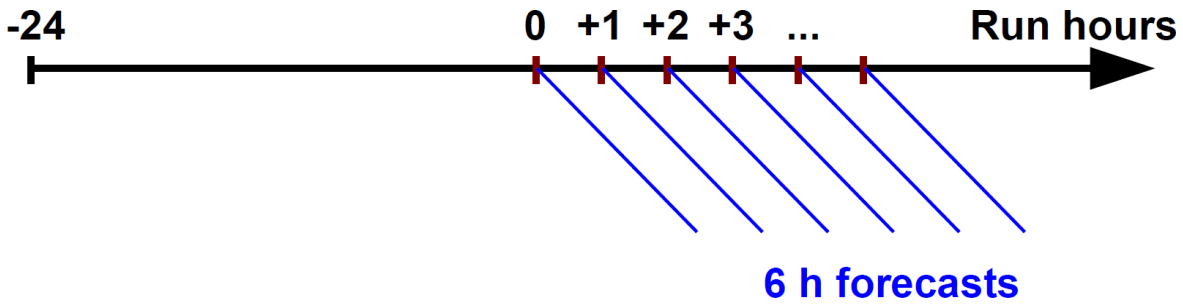
Find optimal case studies



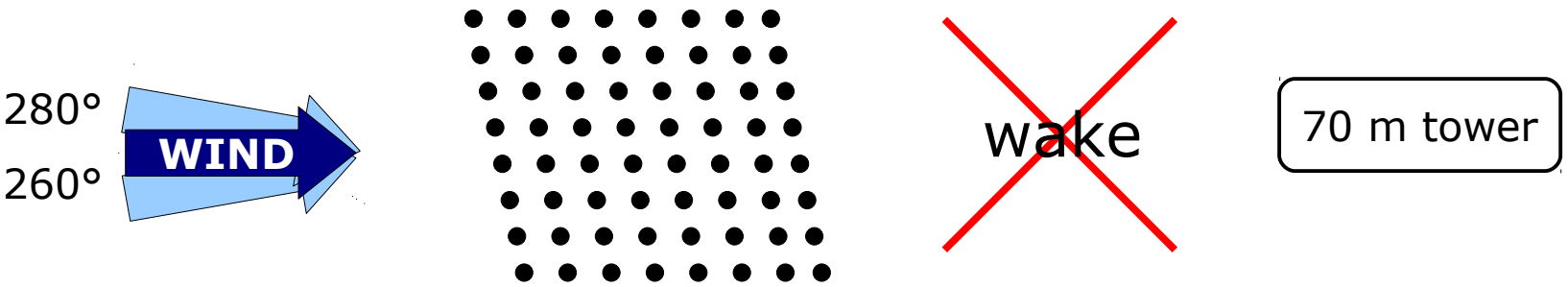
→ 4 days in 4 different months in 2005:

54 hours with a 6h-forecast every hour → 54 forecasts

low pressure over northern Europe, pre or post cold front



Data thinning

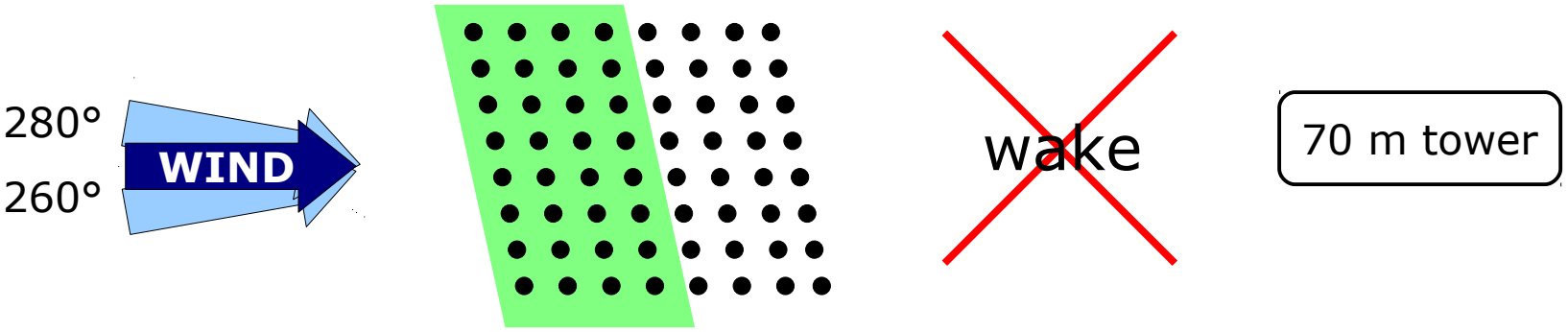


Statistics compared for different turbine groups

Medians of

all turbines

Data thinning

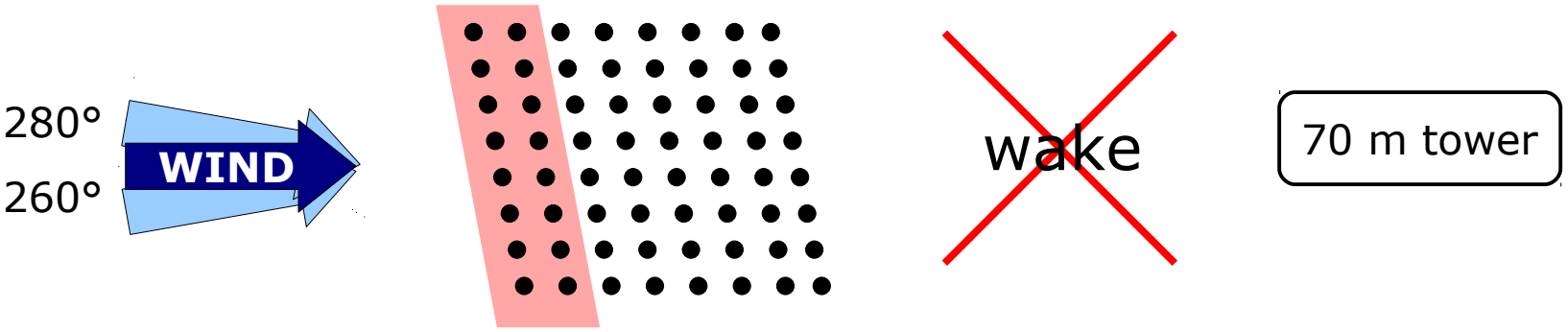


Medians of

all turbines

upwind half farm

Data thinning



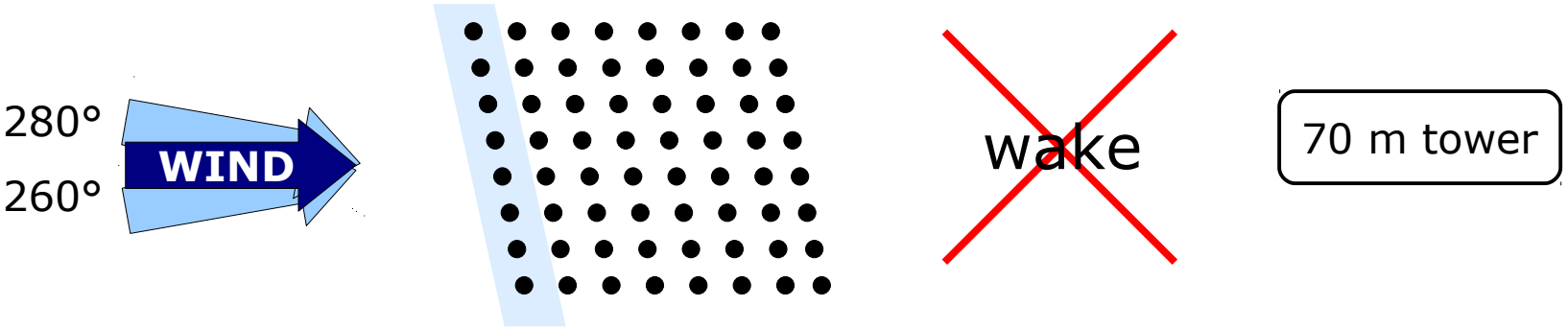
Medians of

all turbines

upwind half

first 2 upwind turbine rows

Data thinning

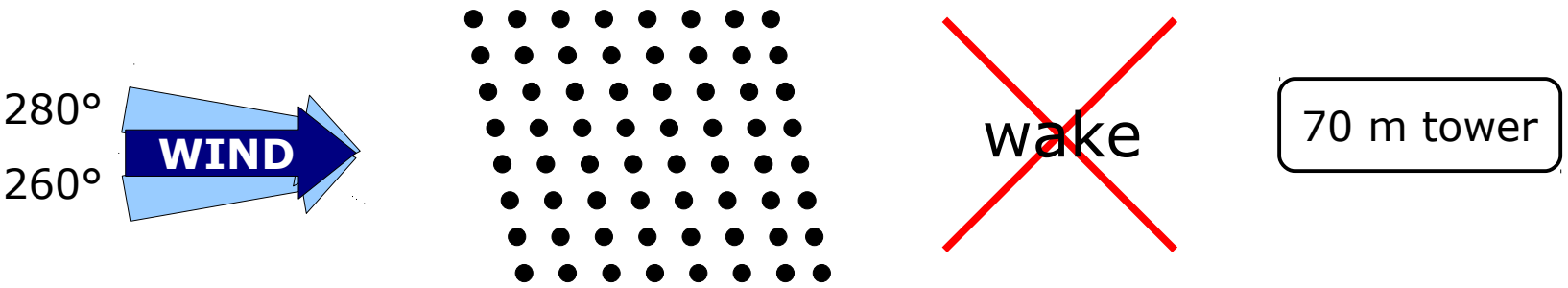


Medians of

- all turbines
- upwind half
- first 2 upwind turbine rows
- first upwind turbine row

Direction measurements from turbine yaws

Data thinning



Medians of

all turbines

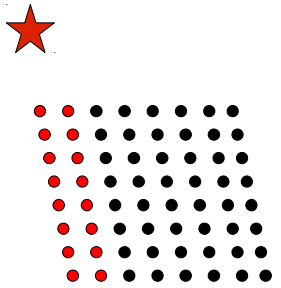
upwind half

first 2 upwind turbine rows

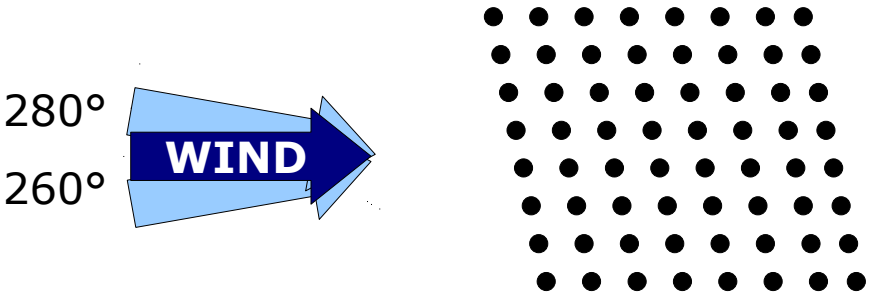
first upwind turbine row

Direction measurements from turbine yaws

and from 68 m tower to the north of the farm



Data thinning



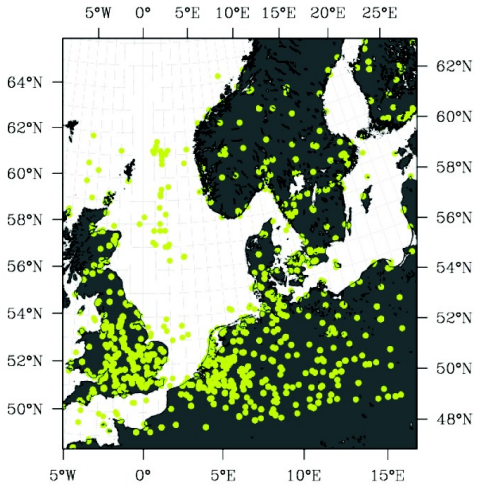
Medians of

all turbines

upwind half

first 2 upwind turbine rows

first upwind turbine row

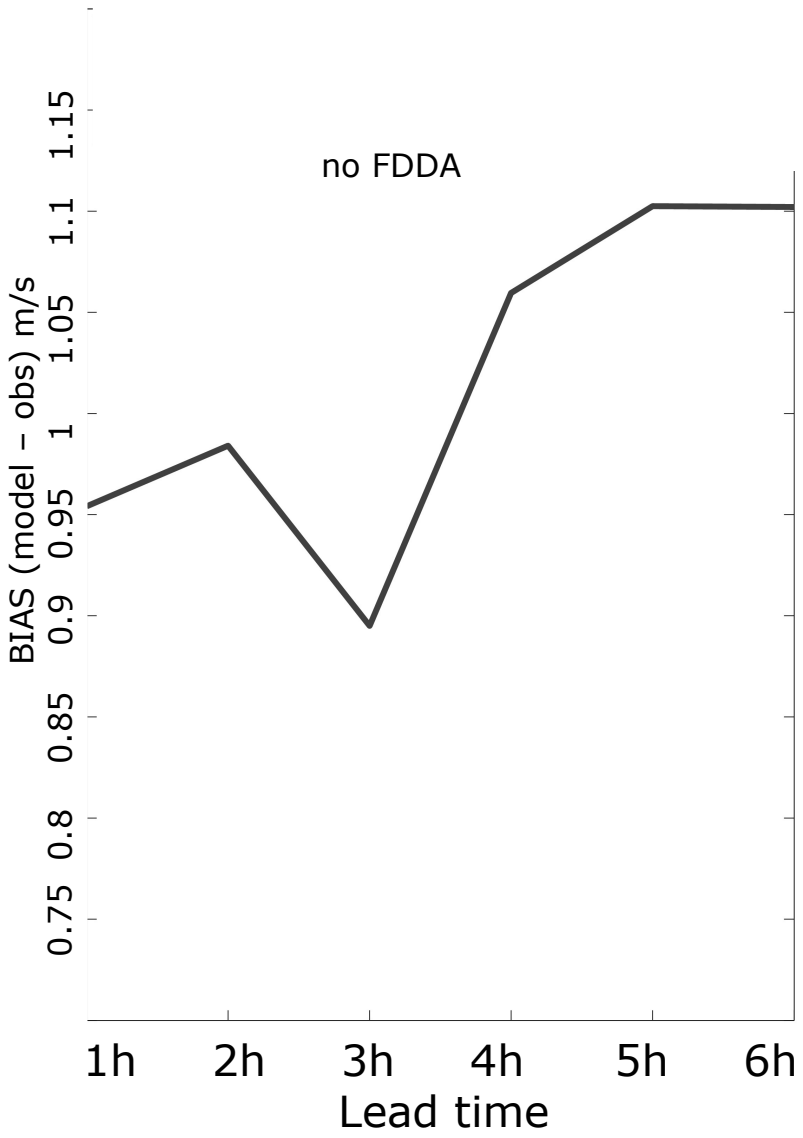


Direction measurements from turbine yaws

and from 68 m tower to the north of the farm

+ METAR, SYNOP, ACARS, Radiosondes, Ships

Bias reduced in first 2 hours, noisy



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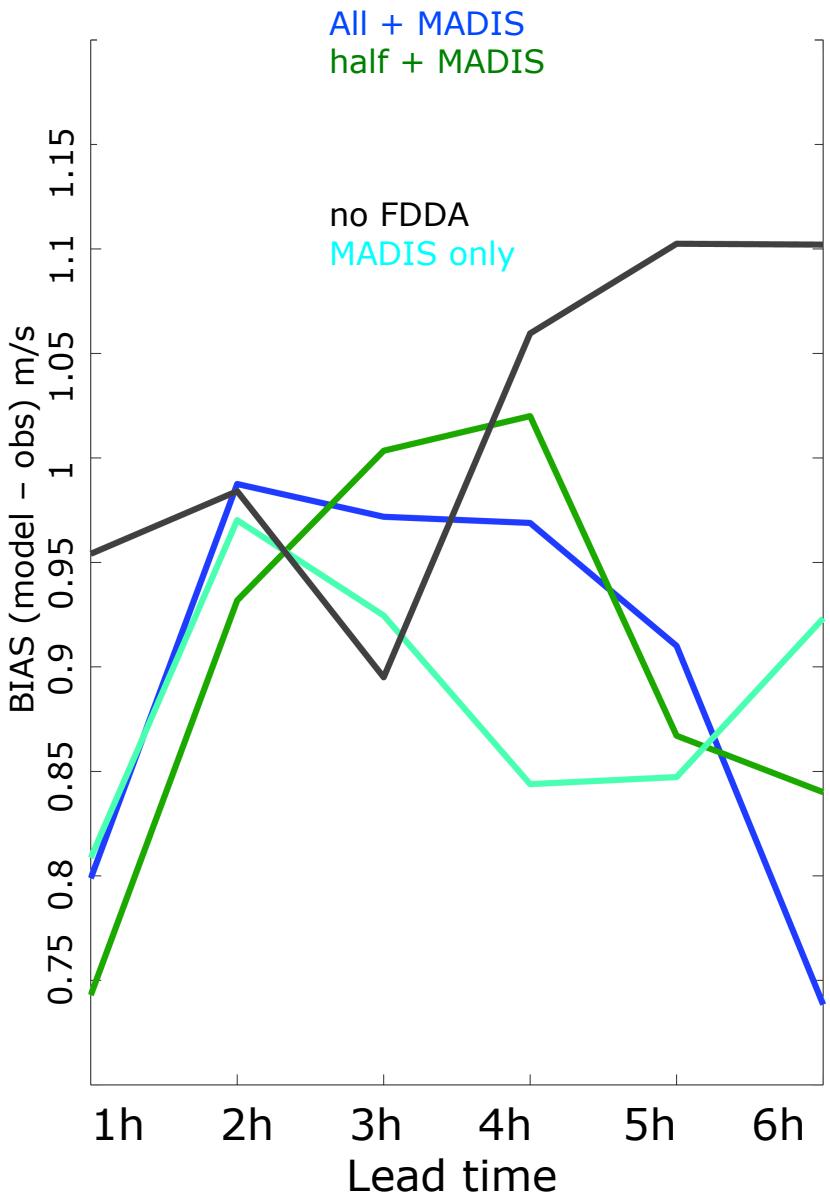

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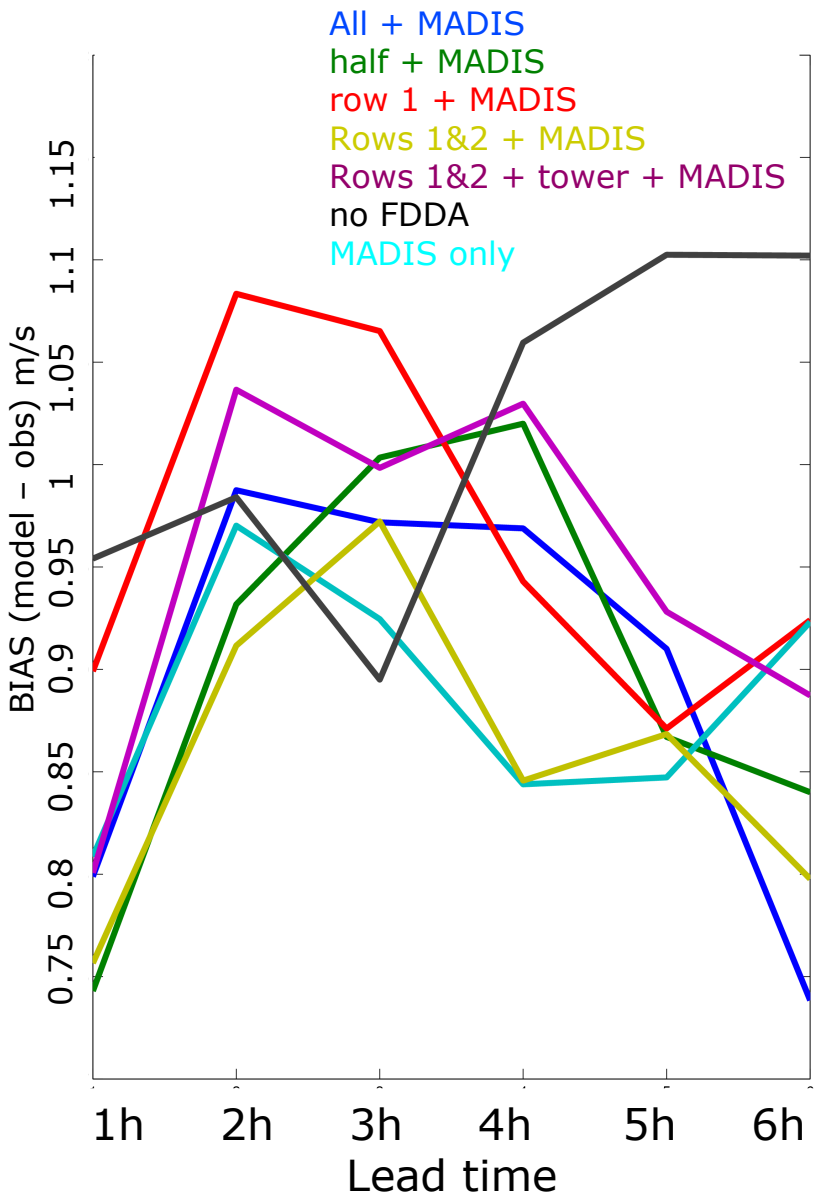
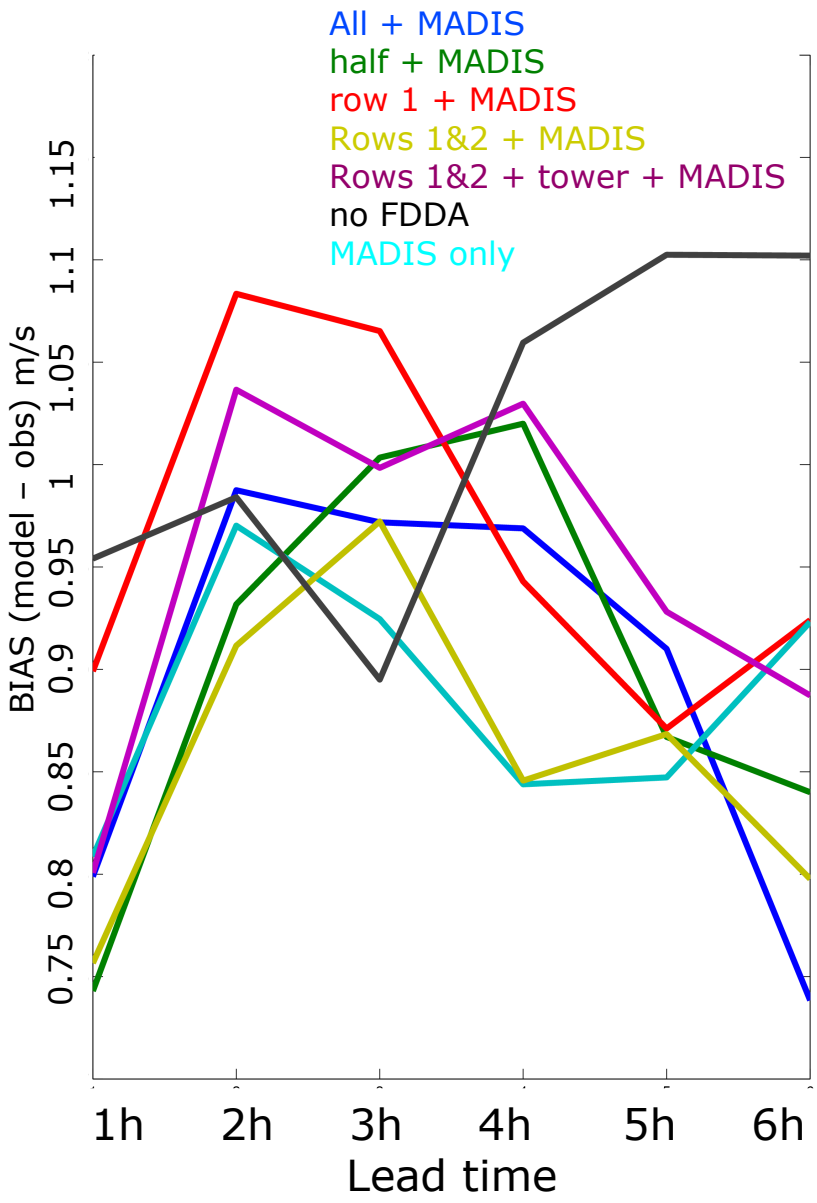
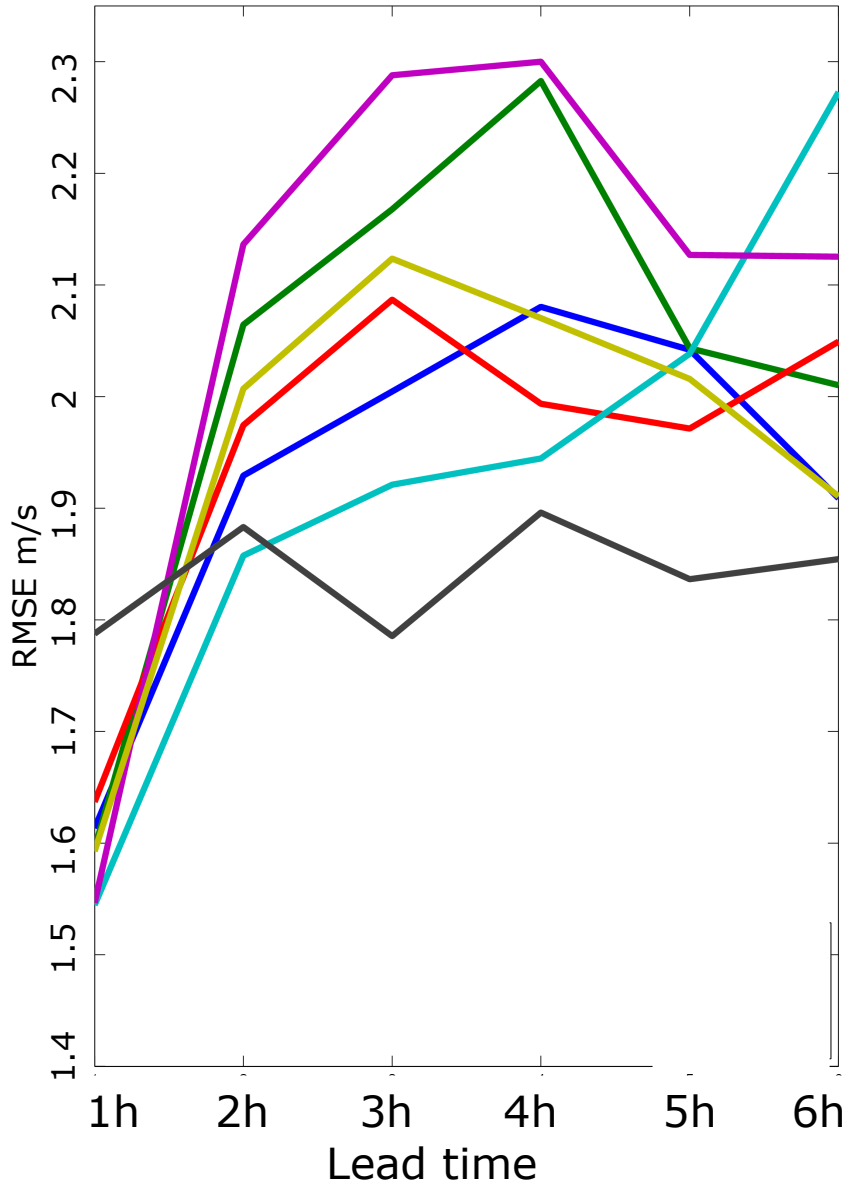


Bias reduced in first 2 hours, noisy





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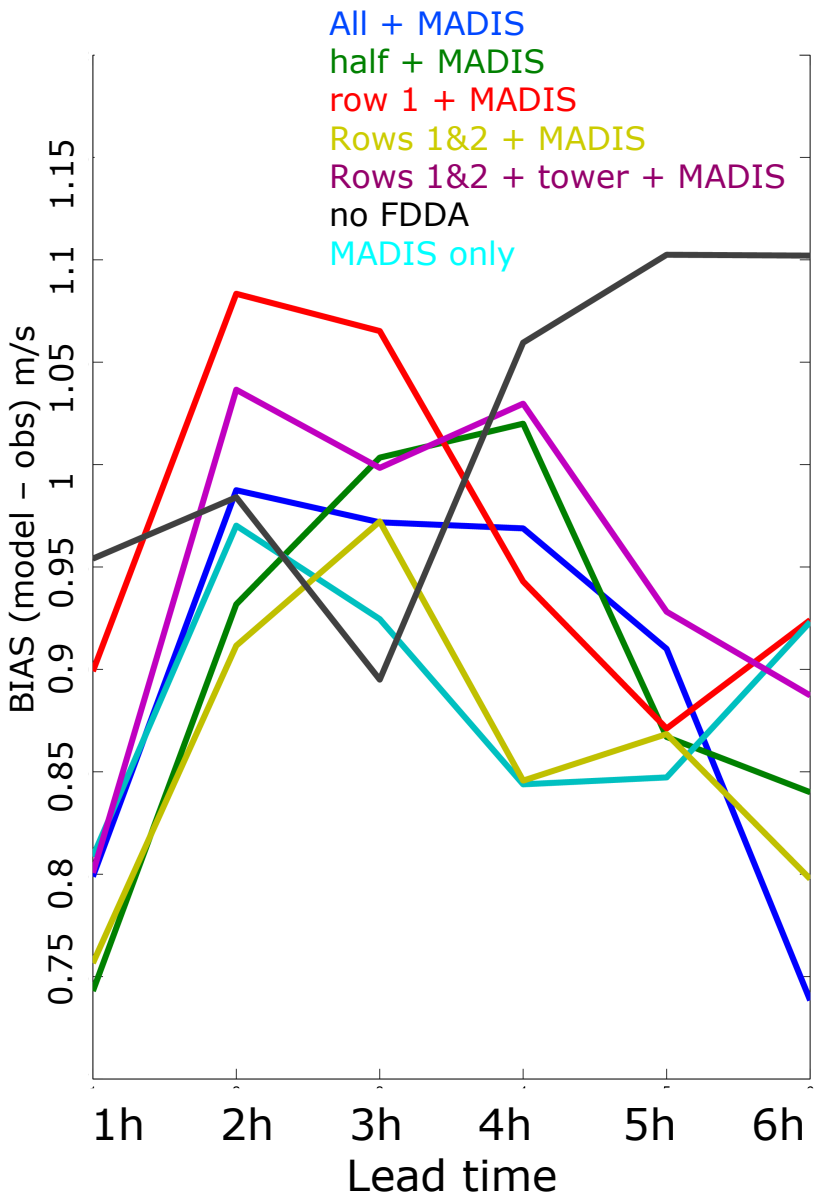
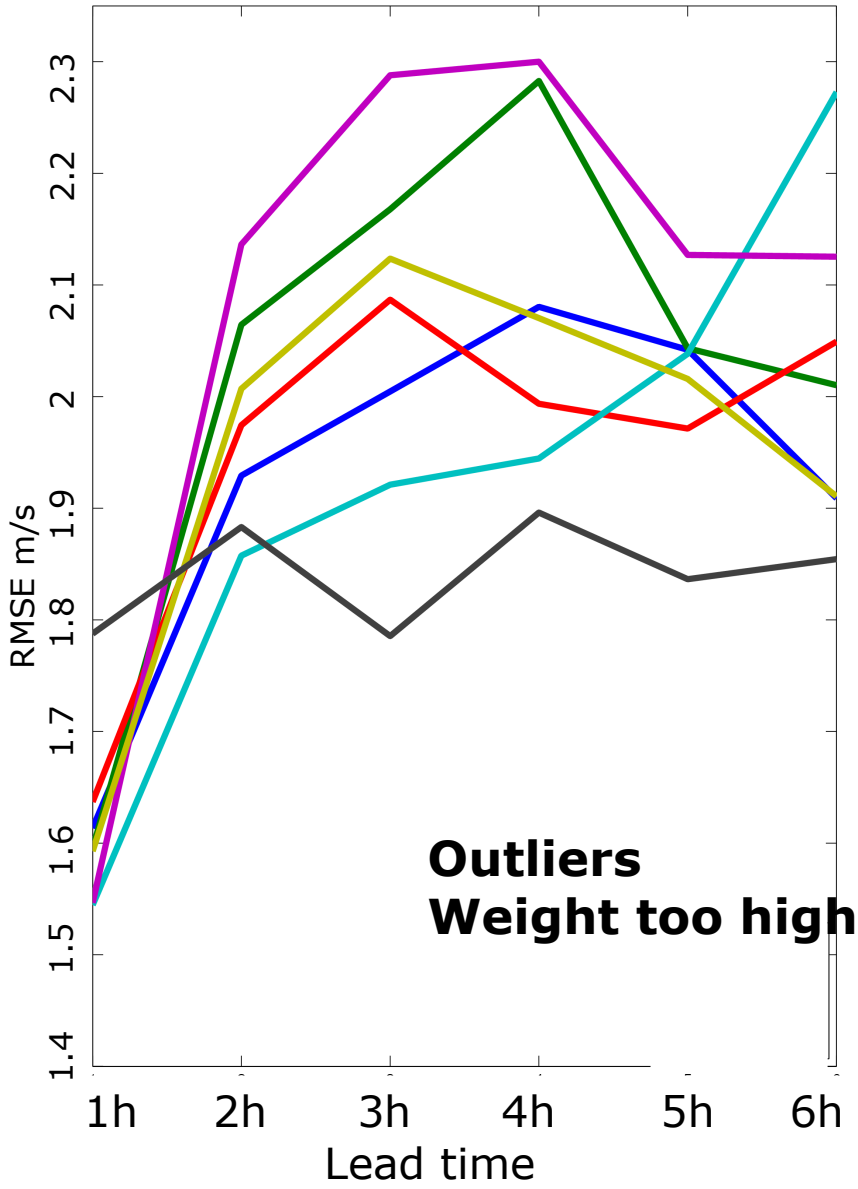
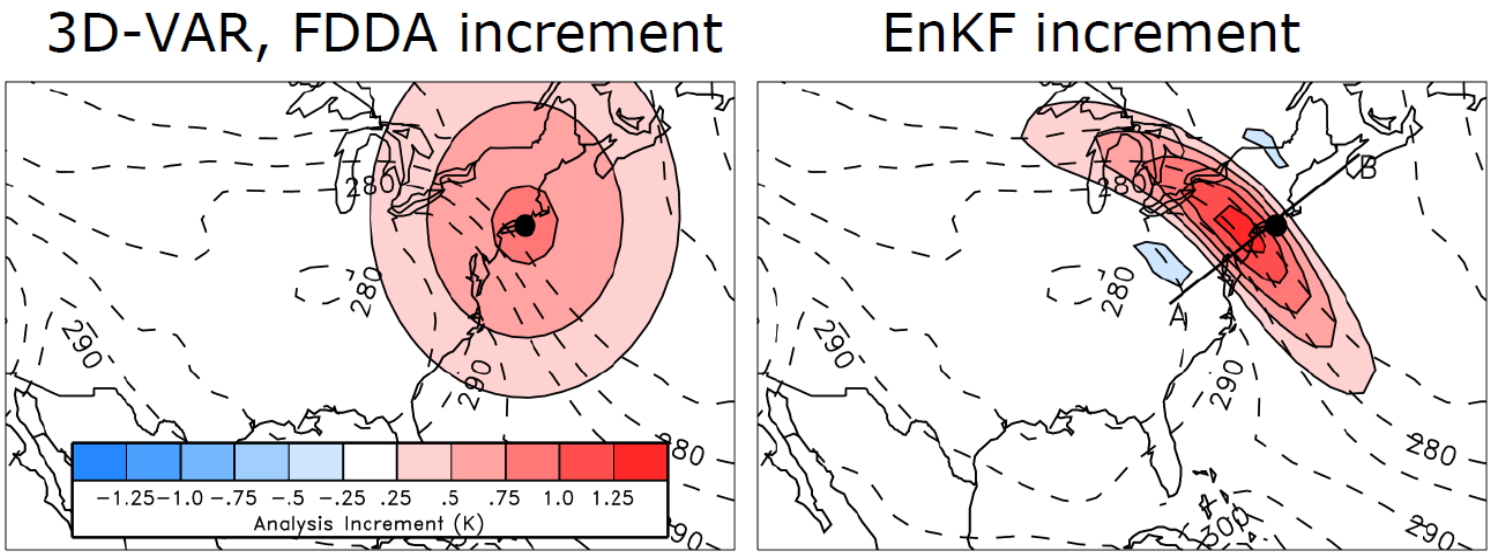




WRF DART and plans

DART: Community Ensemble Kalman filter system maintained by NCAR



Source: Tom Hamill, http://www.esrl.noaa.gov/psd/people/tom.hamill

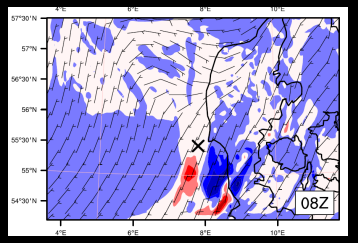
- EnKF: flow-dependent background error covariances.
- Observation error needs to be assigned to measurements – knowledge of measurements is important.
  Observation errors are used by EnKF as a weight for the information provided by the measurements.

A new growing & promising data set

Improve forecasts inland

CAREFUL with nacelle winds !!!

Thinning strategies



FDDA: 2 hour benefit

WRF DART More promising ?

?

Assimilation in the PBL

A new growing & promising data set

Improve forecasts inland

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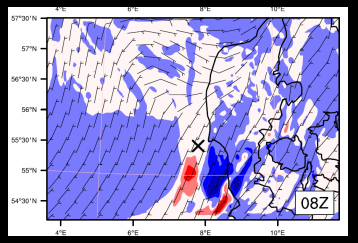
Thinning strategies



FDDA: 2 hour benefit

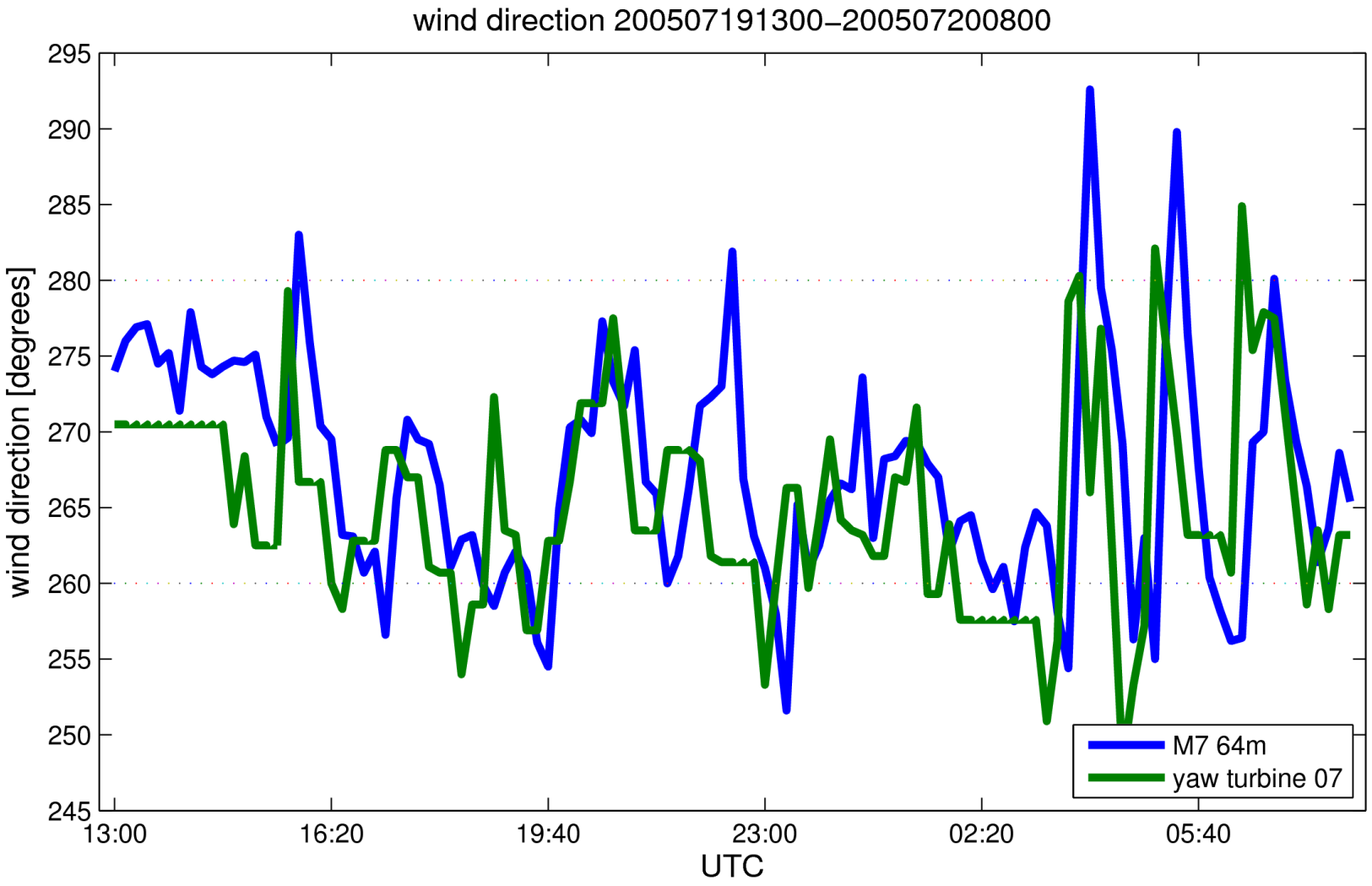
WRF DART More promising ?

?

Assimilation in the PBL

cadr@risoe.dtu.dk

THANK YOU !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wind direction [degrees]
295
290
285
280
275
270
265
260
255
250
245
13:00
16:20
19:40
23:00
02:20
05:40
UTC
M7 64m
yaw turbine 07